Animal performance and meat quality in cull cows with early weaned calves in Argentina

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Abstract

Early weaning of calves (60 days old) is adopted in cow–calf operations for its high reproductive response. The objective of this research work was to find how age classes are related to beef quality in early weaning cull cows. Twenty four cows were grouped in four different age classes (teeth and number of calves produced) from two teeth and no calf produced, up to 12 years and 7 calves produced. All cows grazed a perennial pasture based on alfalfa and fescue. There were differences ($P<0.05$) in final weight (younger cows being lighter) but no other differences could be found during field conditions or in abattoir data (carcass weight and yield, top value hindquarter cuts weight and carcass percent). No differences ($P>0.05$) could be found in meat quality attributes except for moisture, protein and fat yellowness. Differences ($P<0.05$) in sensory attributes could only be found in connective tissue.

1. Introduction

The impact of early weaning of calves (60 days old) on the reproductive performance of cows has been demonstrated in the last thirty years under research and commercial conditions in Argentina (Galli et al. 2005), and other countries. However the effect of the improved cow condition score resulting from early weaning on cull cows meat quality has not been evaluated.

The increasing demand for beef in local and international markets (McCalla & Revoredo, 2001; Pinstrup-Andersen & Pandya-Lorch, 1992; Pinstrup-Andersen & Pandya-Lorch, 1997), especially in local and grass fed beef market, could be partially satisfied by an improved beef quality of cull cows presently used mainly for canning products. These cows are produced in cow–calf operations (Galli, 1984) which is, in itself, a guaranty of an only grass production system. They also graze native pasture except for the finishing period and this means that a minimum amount of fossil fuel is involved in feed production.

When calf crop is over 80%, non pregnant cows are supposed to be culled in every pregnancy diagnosis opportunity. As a result, culled cows will vary in age at culling. Different nutritional levels through life production of dams could also produce different meat quality attributes. These characteristics need to be detected before slaughter as a way to obtain a more uniform beef quality production in order to be appreciated by the client either at the restaurant (Aumaitre, 1999; Harrington, 1994; Vanlogtestijn, 1994) or at home (Goodson et al., 2002).

There is a need for quality standards that could also be estimated at farm level to define the best quality process that will be recorded by traceability of the herd (FAO, 2002; Valin, 2000).

The objective of this work was to assess the effect of age at slaughter on animal performance and meat quality of...
cull cows calving early weaned calves (60 days old) during their whole production life. In addition, the possible identification of estimators of beef quality at farm level will be investigated.

2. Materials and methods

2.1. Animals and experimental design

Twenty four Hereford cows from the Experimental Station (INTA) herd (4.5–5 frame) were allotted to four age treatments, each treatment being an age class. The four treatments were: treatment 1: 3 years old (two teeth) dry cows, no calving; treatment 2: 4–5 years old (four teeth), up to three calving; treatment 3: 6–8 years old (levelled teeth), up to five calving and treatment 4: 12 years (worn out teeth), up to seven calving. Initial weights (average ± standard deviation) before perennial pasture grazing period were: 313.8 ± 26.6 kg; 401.7 ± 40.5 kg; 441.4 ± 50.1 kg and 438.0 ± 39.2 kg for age classes 1, 2, 3 and 4, respectively.

All cows grazed on a perennial pasture of alfalfa (Medicago sativa), white clover (Trifolium repens), birdfoot trefoil (Lotus corniculatus) and fescue (Festuca arundinacea) established in the Experimental Station (32°29′28″ S; 58°20′49″ W, 25 m above mean sea level) in the Province of Entre Ríos in Argentina. After a 140 day finishing period on this pasture, as usual in commercial herds, animals were slaughtered in an officially authorized sanitary and handling controlled (SENASA, National Control Service for Animal Sanitary Status), commercial packing house. The packing house was located 120 km north of the Experimental Station where top value hind quarter cuts (removed at the 10th rib level) were weighed and samples were analyzed in the Meat Industry Lab (University of Entre Ríos).

2.2. Analytical procedures

Half carcass weights were recorded at 1 h post-mortem and carcass yield was estimated by the relationship: hot carcass weight/final weight, in percentage. Carcasses were refrigerated in commercial chambers with forced air circulation (0 ± 2 °C) during 24 h. Top value hind quarter cuts analyzed were: striploin, tenderloin, rump, knuckle, top side cap off, outside flat and eye round roll. All of them were prepared following the SENASA regulations for local market beef cuts. They were all weighed to record partial and total weights and these records were referred as a percentage of half carcass weight.

Several 2.5 cm thick sections of the striploin (mainly L. dorsi muscle) were stored under refrigerated or frozen conditions for the analyses. All the following determinations were made 24 h after slaughter on the striploin steak taken at 12th rib. Subcutaneous fat depth (mm): it was measured at 3/4 of the distance from the longer axe of the section along the vertebra and towards the ribs, as described by Felicio, Picchi, and Corte (1979). Longissimus muscle area (cm²): the muscle section perimeter was first recorded on acetate paper and the area was then determined by a planimeter. Marbling: it was determined by visual comparison according to the standards of the Official United States Standards for Grades of Beef (United States Department of Agriculture, USDA. United States Department of Agriculture., 1997), scale: 1: traces; 2: slight; 3: small; 4: modest; 5: moderate; 6: slightly abundant and 7: moderately abundant. Meat and subcutaneous fat colour were determined using a Minolta colorimeter (Minolta Camera Co., Osaka, Japan), D65 light source and 2° view angle. Lightness L*, redness a* and yellowness b* (CIE, 1978) were evaluated on the L. dorsi and subcutaneous fat at the 12th rib, after keeping the samples 30 min at room temperature. The pH was measured 24 h post-mortem. A portable Parsec Vega I pHmeter was used, with a glass puncture electrode (Oakton, Singapore), recording the average of three readings in the L. dorsi muscle. Warner–Bratzler shear force (WB, N): samples were prepared 48 h post-mortem following the methodology suggested by AMSA (1995). It was determined with a Stable Micro System TA-XT2i (Surrey, England) texture analyser with a Warner–Bratzler cell. The average of six cylinders of 1.3 cm diameter was recorded. An oven (Medcenter, model Venticell 111, Gräfeling, Germany) with automatic temperature control and a temperature recorder with penetration sensor (Testo model 925, Lenzkirch, Germany) was used to follow the thermal process inside the samples. After cooking the samples (at 170 °C to an internal temperature of 70 °C) for tenderness determination, total cooking loss (TL) was determined by subtracting sample weight before and after cooking and expressed as percentage of the initial sample weight. The evaporation cooking loss (EL, volatile substances) was calculated as the difference between total cooking loss and cooking drip loss (DL, separated meat juices by cooking). Fat ( Folch, Lees, & Stanley, 1957) and protein (AOAC, 1999) content of meat (on wet basis) were determined in triplicate. Moisture was determined by rapid method 120 °C, 2 h (Perez-Alvarez et al., 1995) in quintuplicate.

2.3. Sensory evaluation

Samples for sensory evaluation were taken from different sections of the L. dorsi muscle. After cutting they were packed individually in a polyethylene film and frozen at −25 ± 2 °C and then thawed under refrigerated temperature (3 ± 2 °C) before being evaluated. Cooking was carried out in a dry heat oven (170 °C) until 85 °C internal temperature was attained. These processing conditions were chosen because they were similar to those used in the local market to prepare a T-bone steak. The 10 members of the panel were trained in product and terminology. Samples were cut in 2 cm² units and served hot. Flavour, taste, juiciness, connective tissue and off flavour were evaluated following the descriptive analysis methodology suggested by Stone, Sidel, Olier, Woolsey, and Singleton.
A descriptive quantitative trial employing a non-structured scale, with extreme and intermediate points was used (1: without flavour, taste, juiciness, connective tissue and off flavour to 7: very high flavour, taste, juiciness, connective tissue and off flavour).

2.4. Statistical analysis

Data were analyzed using Statistica, v.5 (Statsoft, Inc., Tulsa, OK, USA) for one-way ANOVA. Tukey’s test was used to identify significant differences among treatments and simple correlations between all variables \((P < 0.05)\) were calculated.

3. Results and discussion

3.1. Field results

Final weight out of the pasture differed significantly \((P = 0.0311)\) among age classes. The grand mean was 468.1 kg with a coefficient of variation (CV) of 10.5%. No significant differences were found between age classes except between classes 1 and 3 with the minimum and maximum final weight value respectively (Table 1). Variances were homogeneous. Similar results in so far as weight, age and production system are concerned, were reported in Australia (Wythes & Shorthose, 1991) except for the youngest dams. The corresponding to age class 1 in that experiment had four teeth.

Cull cows with early weaned calves throughout their productive life are not presently distinguished in the market. Consequently, young steers, a highly appreciated category in Argentina, could be used as a comparative value for market quality acceptance, when considering all meat quality parameters.

Results obtained in a previous work carried out on Hereford steers will be used as indicative values due to the fact that in our country there is no bibliography about this topic. The Hereford steers \((n = 6)\) were finished under grazing conditions on the same pasture, and with a similar degree of finishing (Garciaarena et al., 2004; Teira et al., 2004) as the cows in this work.

Age classes did not differ significantly on average daily gain \((P > 0.05)\). The grand mean was 0.526 kg. There was not heterogeneity of variances \((P > 0.05)\). In order to analyze the possible sources of variation, the larger standard deviation was 0.253 kg for age class 3 and the minimum 0.118 kg for age class 1 (Table 1). The indicative mean average daily gain value for a 420 kg steer was 0.650 kg (Garciaarena et al., 2004).

3.2. Abattoir data

Age classes did not differ significantly \((P > 0.05)\) in carcass weight with a grand mean of 233.1 kg and a CV of 10.5%. There was a trend for younger cows to have less carcass weight, however, it stabilizes in the other age classes (Table 1). There was no heterogeneity of variances \((P > 0.05)\). The indicative value for carcass mean weight for a 420 kg steer was 229.7 kg (Garciaarena et al., 2004). Carcass weight is a poor estimator of meat yield (Hopkins & Roberts, 1995) but these results are included in order to be compared with other research workers information. They do not entirely agree with results obtained in Australia (Wythes & Shorthose, 1991) where older cow (eight teeth) carcasses were heavier than those of 4 teeth cows and both were heavier than those of two teeth cows. However a similar trend was observed because two teeth cow carcasses weighed 219.2 kg and the other age classes weighed between 232.6 and 244.5 kg. It might have been that these differences did not seem to be significant because of the small number of replications. This experiment might not have been sensitive enough, according to Wertz, Berger, Faulkner, and Nash (2001) the difference in weight of the younger dams might be attributed to the nutrition levels during the period of heifer active growth, which is a matter of replacement heifer management.

There was a significant age effect on carcass yield \((P = 0.0333)\) but no differences were found in the means comparison by Tukey Test. A slight trend to reduce yield with increasing age could be observed (Table 1). The grand mean was 50.0% and the CV was 3.5%. There was no heterogeneity of variances \((P > 0.05)\) and the extreme values were 48.5 and 52.0% for age classes 4 and 1, respectively.

### Table 1

<table>
<thead>
<tr>
<th>Age classes</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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</thead>
<tbody>
<tr>
<td>Final live weight, kg</td>
<td>422.0 ± 26.7a</td>
<td>461.7 ± 36.7ab</td>
<td>502.6 ± 54.5b</td>
<td>486.2 ± 45.8ab</td>
</tr>
<tr>
<td>Average daily gain, kg</td>
<td>0.575 ± 0.118</td>
<td>0.581 ± 0.182</td>
<td>0.580 ± 0.253</td>
<td>0.367 ± 0.181</td>
</tr>
<tr>
<td>Carcass weight, kg</td>
<td>219.2 ± 12.5</td>
<td>236.3 ± 29.5</td>
<td>244.5 ± 31.8</td>
<td>252.6 ± 25.6</td>
</tr>
<tr>
<td>Carcass yield, %</td>
<td>52.0 ± 2.9</td>
<td>51.0 ± 2.7</td>
<td>48.6 ± 1.5</td>
<td>48.5 ± 1.5</td>
</tr>
<tr>
<td>Total cut weight, kg</td>
<td>29.94 ± 2.16</td>
<td>29.85 ± 4.01</td>
<td>31.57 ± 4.76</td>
<td>29.57 ± 4.00</td>
</tr>
<tr>
<td>Total cut weight, %</td>
<td>24.65 ± 6.46</td>
<td>25.25 ± 1.74</td>
<td>24.05 ± 5.26</td>
<td>25.41 ± 1.54</td>
</tr>
</tbody>
</table>

a 1:3 years old (2 teeth) no calving; 2: 4–6 years old (four teeth), up to three calving; 3: 6–9 years old (levelled teeth), up to five calving; 4: 12 years (worn out teeth), up to seven calving.

b Different letters in the same row indicate significant differences \((P < 0.05)\).
An important difference with the steer slaughtered at 420 kg was observed in yield. The average yield found for the steers was 55.2% (Garciarena et al., 2004), about five points below in cull cows carcass yield. In consequence this difference will be projected to the live animal market price. In Australia the eight teeth cows had a lower yield (Wythes & Shorthose, 1991) than the other age classes. This difference could not be detected in this experiment.

There was not an age class effect on special hindquarter valuable cuts total weight ($P > 0.05$, Table 1). If these results are compared to the selected indicative value: the 420 kg weight two teeth steer, the average total cut weights for cull cow age classes (30.23 kg) seemed slightly higher than the 28.75 kg of the corresponding value for this steer (Garciarena et al., 2004).

Age classes did not differ in percentage of special hindquarter valuable cuts total weight (Table 1) referred to half carcass weight ($P > 0.05$). The grand mean was 24.84% with a CV of 6.7%. There was no heterogeneity of variances ($P > 0.05$). These results agree with those of other authors (Jeremiah, Aalhus, Robertson, & Gibson, 1997) where no differences were found between categories and body condition scores for these traits. Although special hindquarter valuable cuts weight seemed to be somewhat higher when compared with the reference steer value, the final percent was similar in both cases (the indicative value for the steer category was 25.01%).

### 3.3. Meat quality

No significant effect of age class ($P > 0.05$, Table 2) was found in longissimus muscle area (LMA). The grand mean was 61.02 cm$^2$ and the CV was 12.2%. The probability value of the Bartlett’s test was 0.1423. In order to detect the source of variation and whether it could be attributed to age class, a lower standard deviation with age classes was observed. A more uniform product could be obtained from older cull cows. The larger variances in the younger cull cows could also be attributed to the heifer nutrition levels reported by Wertz et al. (2001). The indicative value of LMA for a 420 kg steer was 59.67 cm$^2$ (Garciarena et al., 2004), quite similar to the grand mean for cows and even less than the LMA found in age classes 1 and 4. LMA is a very important estimator of meat yield and quality attributes. It can be determined in live animals (Bruckmaier, Lehmann, Hugi, Hammon, & Blum, 1998) by means of ultrasound equipment (Griffin, Savell, Recio, Garrett, & Cross, 1999; Hassen, Wilson, Willham, Rouse, & Trenkle, 1998). Uniformity of the product is a very important process quality attribute. In order to cut down standard deviation in LMA, heifer nutrition levels will have to be reconsidered.

Age class effect on subcutaneous fat thickness (FT, Table 2) was not significant ($P > 0.05$) with a grand mean of 8.85 mm and CV of 28.7%. The large CV and the probability of age class effect very near to 0.10 point were probably due to the lack of uniformity of the operator in determining the slaughter point in cull cow fattening operation. This demands a general commercial use of non-subjective determination for fatness degree.

The indicative value (the average 420 kg fat steer FT value) was 7.33 mm with a CV of 24.4% (Teira et al., 1998). Uniformity of the product is a very important estimator of meat yield and quality attributes. It can be determined in live animals (Bruckmaier, Lehmann, Hugi, Hammon, & Blum, 1998) by means of ultrasound equipment (Griffin, Savell, Recio, Garrett, & Cross, 1999; Hassen, Wilson, Willham, Rouse, & Trenkle, 1998). Uniformity of the product is a very important process quality attribute. In order to cut down standard deviation in LMA, heifer nutrition levels will have to be reconsidered.

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The indicative value (the average 420 kg fat steer FT value) was 7.33 mm with a CV of 24.4% (Teira et al., 2004). This difference in CV would be attributed to steers with similar management and feeding levels (same perennial pasture and same weaning time) while a cull cow may have very different nutritional and management history due to the heterogeneity of native pastures, age at weaning and pregnancy rates. All cull cow fat thickness values were higher than 5 mm, a minimum value accepted to identify tenderness with the categories of the U.S.D.A. grading system (Jones & Tatum, 1994) and could be fitted to A1 category in the Canadian grading system (Jeremiah

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Table 2

<table>
<thead>
<tr>
<th>Age classes</th>
<th>1</th>
<th>2</th>
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<tbody>
<tr>
<td>LMA (cm$^2$)</td>
<td>63.64 ± 10.68</td>
<td>58.25 ± 7.33</td>
<td>57.97 ± 7.69</td>
<td>64.24 ± 5.32</td>
</tr>
<tr>
<td>FT (mm)</td>
<td>8.20 ± 2.05</td>
<td>11.0 ± 3.69</td>
<td>9.86 ± 4.22</td>
<td>6.33 ± 1.37</td>
</tr>
<tr>
<td>Marbling score</td>
<td>2.90 ± 0.74</td>
<td>3.67 ± 0.82</td>
<td>2.79 ± 1.22</td>
<td>2.83 ± 0.75</td>
</tr>
<tr>
<td>pH24</td>
<td>5.52 ± 0.03</td>
<td>5.51 ± 0.03</td>
<td>5.53 ± 0.09</td>
<td>5.56 ± 0.08</td>
</tr>
<tr>
<td>Meat colour</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightness, $L^*$</td>
<td>34.64 ± 2.32</td>
<td>32.32 ± 1.14</td>
<td>32.80 ± 2.51</td>
<td>35.22 ± 2.55</td>
</tr>
<tr>
<td>Redness, $a^*$</td>
<td>19.25 ± 2.00</td>
<td>18.72 ± 2.40</td>
<td>19.71 ± 2.53</td>
<td>17.61 ± 2.10</td>
</tr>
<tr>
<td>Yellowness, $b^*$</td>
<td>5.26 ± 1.10</td>
<td>4.29 ± 1.64</td>
<td>5.52 ± 1.26</td>
<td>4.77 ± 1.37</td>
</tr>
<tr>
<td>Fat colour</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightness, $L^*$</td>
<td>65.34 ± 4.73</td>
<td>64.58 ± 2.38</td>
<td>64.63 ± 5.44</td>
<td>66.97 ± 2.74</td>
</tr>
<tr>
<td>Redness, $a^*$</td>
<td>7.84 ± 3.03</td>
<td>7.20 ± 2.74</td>
<td>5.46 ± 1.87</td>
<td>5.76 ± 2.15</td>
</tr>
<tr>
<td>Yellowness, $b^*$</td>
<td>15.53 ± 1.59</td>
<td>19.28 ± 2.87</td>
<td>21.58 ± 3.23</td>
<td>23.45 ± 4.45</td>
</tr>
</tbody>
</table>

LMA: *longissimus* muscle area.
FT: subcutaneous fat thickness.
Marbling score, scale: 1: traces, 7: moderately abundant.

$^a$ 1:3 years old (two teeth) no calving; 2: 4–5 years old (four teeth), up to three calving; 3: 6–8 years old (levelled teeth), up to five calving; 4: 12 years (worn out teeth), up to seven calving.

$^b$ Different letters in the same row indicate significant differences ($P < 0.05$).
et al., 1997). According to Tatum, Smith, and Carpenter (1982) interrelations between marbling and subcutaneous fat thickness with cooked beef palatability in carcasses with a FT of 7.6–10.2 mm (12th–13th rib level) could be regarded as 90% acceptable from a palatability standpoint.

The marbling degree (Table 2) showed an extremely high CV: 62.2%, as expected in agreement with dorsal fat depth values. Probably, this is the reason for a lack of age class effect observed in this parameter (P > 0.05). The grand mean was 3.05 which, according to the adopted scale, corresponded to a small marbling degree. The problem of high variation in degree of finishing is common to all age classes. The overall correlation for all age classes between FT and marbling was significant and positive (r = 0.53; P < 0.05). The reason for the importance of this correlation lies on the fact that the field operator could manage and determine this FT while marbling is one of the quality indicators the buyer can see on the shelf, especially if beef is exported to certain markets like the Japanese market.

Age class did not differ significantly in pH (P > 0.05 Table 2). The grand mean for all age classes was 5.53 and the CV was very low (1.2%). The probability of heterogeneity of variances was P > 0.05. The indicative pH value for a 420 kg steer was 5.42 (not published). The maximum pH value recorded was 5.62 which, according to Thomson, Dobbie, Cox, and Simmons (1999) may be regarded as acceptable because it is lower than the 5.7, maximum value suggested. They considered that field management before slaughter must be taken into account in order to cut down pH in beef. Consequently, perennial pasture grazing might be considered acceptable by the client from the pH value standpoint (process quality).

There was no significant age class effect (P > 0.05, Table 2) on meat lightness (L*). The grand mean was 33.74 and the CV was 5.9%. There was no heterogeneity of variances (P > 0.05). The 420 kg steer indicative value for L* was 35.04 (Teira et al., 2004). In a very complete review of grass feeding and colour, Priolo, Micol, and Agabriel (2001) concluded that even despite the fact that colour is poorly attributable to the client discriminates against and therefore, it results in lower meat price (Kögel, Grabrucker, Pickl, & Rutzmoser, 1997). Carotene content of the diet, the reason for the yellow colour (Mancini & Hunt, 2005; Realini, Williams, Pringle, & Bertrand, 2001) can be reduced supplying either corn silage (Kögel et al., 1997) during the last 90 day finishing period or concentrates (Daly, Young, Graaffuis, Moorhead, & Easton, 1999). However in the latter case, such improvement may result in modification of fat acids profile (Garcia et al., 2005; Yang, Lanari, Brewster, & Tume, 2002) as well as tocopherol content and an increase of lipidic oxidation (Descalzo et al., 2005) of meat.

A summary of tenderness, cooking loss, chemical composition and sensory attributes is presented in Table 3 in order to compare age class effects and as a contribution to future meat quality standards. No significant differences were detected in WB shear force among age classes (P > 0.05). The grand mean for this trait was 51.65 N, the CV was relatively high: 24.4% and there was no heterogeneity of variances (P > 0.05). These values are for fresh meat, if transportation is involved, there could be an ageing process which has not been analyzed in this work. Wythes and Shorthose (1991) could not find an age effect on shear force. Another point to take into account is that 60% of the...
### Table 3

Meat quality, chemical composition and sensory traits of cull cows with early weaned calves

<table>
<thead>
<tr>
<th>Age classes</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB (N)</td>
<td>50.27 ± 15.29</td>
<td>57.13 ± 14.11</td>
<td>53.21 ± 8.92</td>
<td>45.96 ± 10.78</td>
</tr>
<tr>
<td>Total cooking loss,</td>
<td>14.82 ± 5.20</td>
<td>16.48 ± 3.55</td>
<td>18.69 ± 3.70</td>
<td>14.36 ± 3.22</td>
</tr>
<tr>
<td>Evaporation loss,</td>
<td>7.95 ± 2.29</td>
<td>9.21 ± 2.85</td>
<td>10.29 ± 2.28</td>
<td>7.79 ± 0.73</td>
</tr>
<tr>
<td>Cooking drip loss</td>
<td>6.87 ± 2.97</td>
<td>7.27 ± 1.23</td>
<td>8.39 ± 1.77</td>
<td>6.57 ± 3.04</td>
</tr>
</tbody>
</table>

**Chemical composition**

- **Moisture**
  - Age class 1: 74.13 ± 0.59ab
  - Age class 2: 73.54 ± 0.70b
  - Age class 3: 74.49 ± 0.80b
  - Age class 4: 75.26 ± 0.95a

- **Protein**
  - Age class 1: 23.05 ± 1.49a
  - Age class 2: 22.02 ± 0.84ab
  - Age class 3: 21.63 ± 1.00ab
  - Age class 4: 21.23 ± 0.50b

- **Lipid**
  - Age class 1: 2.57 ± 1.21
  - Age class 2: 2.54 ± 0.47
  - Age class 3: 2.92 ± 0.76
  - Age class 4: 1.97 ± 0.32

**Sensory traits**

- **Flavour**
  - Age class 1: 4.10 ± 0.50
  - Age class 2: 4.59 ± 0.54
  - Age class 3: 3.89 ± 0.26
  - Age class 4: 4.06 ± 0.45

- **Taste**
  - Age class 1: 4.01 ± 0.43
  - Age class 2: 3.79 ± 0.39
  - Age class 3: 3.72 ± 0.50
  - Age class 4: 3.53 ± 0.38

- **Juiciness**
  - Age class 1: 3.12 ± 0.71
  - Age class 2: 2.96 ± 0.72
  - Age class 3: 2.76 ± 0.76
  - Age class 4: 2.97 ± 0.70

- **Connective tissue**
  - Age class 1: 1.71 ± 0.43a
  - Age class 2: 2.16 ± 0.39ab
  - Age class 3: 2.52 ± 0.40b
  - Age class 4: 2.21 ± 0.53ab

- **Off-flavours**
  - Age class 1: 1.52 ± 0.52
  - Age class 2: 1.56 ± 0.37
  - Age class 3: 1.41 ± 0.16
  - Age class 4: 1.55 ± 0.55

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*ab Different letters in the same row indicate significant differences (P < 0.05).*

c Scale: 1: without flavour, taste, juiciness, connective tissue and off-flavour to 7: very high flavour, taste, juiciness, connective tissue and off-flavour.

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**WB values**

Global data recorded in the cull cows were below 49 N. Consequently there is a high possibility for selection either in breeding operations or just in the field before transportation. Considering the high CV, the fact that shear force variation heightens with an increasing cutting resistance (Dugan & Aalhus, 1998) must be taken into account. Even in spite of the small sample size and the high CV, the value for the correlation between WB shear force and LMA were \( r = -0.59 \) \((P < 0.05)\). This is extremely important because LMA can be measured in the live animal and this value could be recorded in a traceability system. There is also a possibility for the operator to select animals before transportation to the packing house according to the tenderness standards required by the market.

Although techniques to simplify sampling in the packing house (Koolmaraie, Shackelford, & Wheeler, 1998) have been developed it can be taken for granted that they are very expensive and time consuming. This is the reason why availability of field determinations, that are easily and cheaply operated, could be very interesting. The analyses of consumer preferences have shown that the packing house should target a WB of 40.2 N or below in meat in order to attain high levels of consumer acceptance (Huffman et al., 1996) will depend on where he is eating (Miller et al., 1995). At home, the degree of acceptance will rank between 45 and 49 N and at the restaurant it will be between 42 and 51 N.

Age classes did not differ in evaporation loss \((P > 0.05)\) (Table 3). The grand mean was 7.27\% and the CV was rather high: 32.5\%. There was no heterogeneity of variances \((P > 0.05)\). There was not an age class effect on total cooking loss \((P > 0.05)\). The grand mean was 16.09\% and the CV was 24.5\%. The average total cooking loss for the indicative 420 kg steer was 12.70\% (Teira et al., 2004). Other researchers (Wythes & Shorthose, 1991) could not find effects of either chronological or by teeth age on cooking loss. Values found for all age classes resulted to be largely below those reported by Rubio L, Méndez M, and Huerta-Leidenz (2007). They argue that values between 24 and 30\% are similar to those reported by other authors. The importance of the results reported here is that some authors (Destefanis, Barge, Brugiapaglia, & Tassone, 2000; Serra et al., 2004; Silva, Patarata, & Martins, 1999) have suggested that higher loss might negatively affect some organoleptic characteristics of meat like juiciness and tenderness.

Moisture content differed significantly among age classes \((P = 0.0025)\). The grand mean was 74.10\% with a very low CV: 0.98\%. It might be interesting to analyze the standard deviation coefficients (Table 3). The very low intra-class correlation is reflected in the general CV. The minimum standard deviation coefficient recorded was for age class 1, and the maximum for age class 4. There is not a definitive trend. The corresponding reference mean value for steers was 73.07\%, quite similar to the cull cows. Moisture content was carefully analyzed because in a previous paper by the same authors (Teira et al., 2004) this parameter was positively related to tenderness in feedlot finished steers. In this experiment the correlation between moisture content and WB shear force \((r = -0.45)\) was significant \((P < 0.05)\). It might be another way to obtain reference for tenderness in the packing house with a cheaper determi-
nation in future experiments. It could also be included together with LMA in a mathematical model to estimate tenderness in larger samples that those collected for tenderness determination under commercial conditions. In this case, a cheaper indirect sampling for moisture determination will have to be adapted.

Age classes did not differ in total lipid contents \( (P > 0.05, \text{Table 3}) \). The grand mean for all treatments was 2.49\% with a CV of 30.2\%. It resulted high for the younger age class.

Age classes differed in muscle protein content \( (P = 0.0396) \), with significant differences between age classes 1 (23.01\%) and 4 (21.23\%, \text{Table 3}). This could be attributed to the variation observed in moisture content discussed above, due to the fact that all chronological ages were above 2 years. According to Renerre (1990) myoglobin content increases with age only until 24 months and it depends on breed and on the muscle considered.

No age class effect \( (P > 0.05) \) was observed on flavour, taste, juiciness and off flavour (grand mean: 4.16; 3.76; 2.95 and 1.51 respectively, \text{Table 3}). According to the rank used (1–7) flavour and taste were classified as intermediary while juiciness was considered in all cases below this level. These results agree with those reported by Schnell, Belk, Tatum, Miller, and Smith (1997) who did not find differences in juiciness and flavour intensity when analyzing cull cows meat (4–10 years old) from different breeds and using different periods for determination. There was a significant age class effect on connective tissue \( (P = 0.0397) \). It was classified, in general terms, as a relative low level while a ageing might be the case. The increased connective tissue level could be related to an increase with cow age in intermolecular cross links of the collagen fibres (Aberle et al., 2001). Off flavour can be regarded as very small or absent in all cases. From an organoleptic standpoint, beef produced by all cull cow age classes might be regarded as similar among them and acceptable for the consumer. Especially if it is considered that flavour and taste have been classified as similar to the steer indicative value (4.17 and 3.94 flavour and taste, respectively) and even though juiciness has been classified in a lower score when compared to these steers (2.97 vs. 4.87, respectively) (Teira et al., 2004).

4. Conclusions

There were differences in final weight, younger cows being lighter in the age classes studied but no other differences were found during field conditions nor in the abattoir data: average daily gain, carcass weight and yield, top value hindquarter cuts weight and carcass percent.

No differences were found in meat quality attributes except for moisture, protein and \( b^* \) values in fat colour. Fat yellowness increased with age classes. Tenderness showed interesting values for this category. Furthermore, significant correlations between this trait and the longissimus muscle area, moisture and cooking losses were observed.

Differences in sensory attributes were only found in connective tissue. With regard to the organoleptic standpoint the cull cow meat could be considered acceptable.

Finally, the early weaning system does not only improve cow reproductive behaviour but also, according to this assay, could produce acceptable quality cull cow meat.

References


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